

Data Confidentiality:

Identifying and Protecting Assets Against Data Breaches

Volume B:
Approach, Architecture, and Security Characteristics

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December 2023

DRAFT

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<https://www.nccoe.nist.gov/data-confidentiality-identifying-and-protecting-assets-against-data-breaches>

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9 National Institute of Standards and Technology Special Publication 1800-28B, Natl. Inst. Stand. Technol.
10 Spec. Publ. 1800-28B, 61 pages, (December 2023), CODEN: NSPUE2

11 **FEEDBACK**

12 You can improve this guide by contributing feedback. As you review and adopt this solution for your
13 own organization, we ask you and your colleagues to share your experience and advice with us.

14 Comments on this publication may be submitted to: ds-nccoe@nist.gov

15 Public comment period: December 13, 2023 through January 15, 2024

16 All comments are subject to release under the Freedom of Information Act.

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23 **NATIONAL CYBERSECURITY CENTER OF EXCELLENCE**

24 The National Cybersecurity Center of Excellence (NCCoE), a part of the National Institute of Standards
25 and Technology (NIST), is a collaborative hub where industry organizations, government agencies, and
26 academic institutions work together to address businesses' most pressing cybersecurity issues. This
27 public-private partnership enables the creation of practical cybersecurity solutions for specific
28 industries, as well as for broad, cross-sector technology challenges. Through consortia under
29 Cooperative Research and Development Agreements (CRADAs), including technology partners—from
30 Fortune 50 market leaders to smaller companies specializing in information technology security—the
31 NCCoE applies standards and best practices to develop modular, adaptable example cybersecurity
32 solutions using commercially available technology. The NCCoE documents these example solutions in
33 the NIST Special Publication 1800 series, which maps capabilities to the NIST Cybersecurity Framework
34 and details the steps needed for another entity to re-create the example solution. The NCCoE was
35 established in 2012 by NIST in partnership with the State of Maryland and Montgomery County,
36 Maryland.

37 To learn more about the NCCoE, visit <https://www.nccoe.nist.gov/>. To learn more about NIST, visit
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39 **NIST CYBERSECURITY PRACTICE GUIDES**

40 NIST Cybersecurity Practice Guides (Special Publication 1800 series) target specific cybersecurity
41 challenges in the public and private sectors. They are practical, user-friendly guides that facilitate the
42 adoption of standards-based approaches to cybersecurity. They show members of the information
43 security community how to implement example solutions that help them align with relevant standards
44 and best practices, and provide users with the materials lists, configuration files, and other information
45 they need to implement a similar approach.

46 The documents in this series describe example implementations of cybersecurity practices that
47 businesses and other organizations may voluntarily adopt. These documents do not describe regulations
48 or mandatory practices, nor do they carry statutory authority.

49 **ABSTRACT**

50 Attacks that target data are of concern to companies and organizations across many industries. Data
51 breaches represent a threat that can have monetary, reputational, and legal impacts. This guide seeks to
52 provide guidance concerning the threat of data breaches, exemplifying standards and technologies that
53 are useful for a variety of organizations defending against this threat. Specifically, this guide seeks to
54 help organizations identify and protect assets, including data, against a data confidentiality attack.

55 **KEYWORDS**

56 asset management; cybersecurity framework; data breach; data confidentiality; data protection;
57 identify; malicious actor; malware; protect; ransomware

58 **ACKNOWLEDGMENTS**

59 We are grateful to the following individuals for their generous contributions of expertise and time.

Name	Organization
Jason Winder	Avrio Software (now known as Aerstone)
Trey Doré	Cisco
Matthew Hyatt	Cisco
Randy Martin	Cisco
Peter Romness	Cisco
Bryan Rosensteel	Cisco
Micah Wilson	Cisco
Ben Burke	Dispel
Fred Chang	Dispel
Matt Fulk	Dispel
Ian Schmertzler	Dispel
Kenneth Durbin	FireEye
Tom Los	FireEye
J.R. Wikes	FireEye
Jennifer Cawthra	NIST
Joe Faxlanger	PKWARE
Victor Ortiz	PKWARE
Jim Wyne	PKWARE

Name	Organization
Steve Petruzzo	Qcor
Billy Stewart	Qcor
Norman Field	StrongKey
Patrick Leung	StrongKey
Arshad Noor	StrongKey
Dylan Buel	Broadcom Software
Sunjeet Randhawa	Broadcom Software
Paul Swinton	Broadcom Software
Spike Dog	The MITRE Corporation
Sallie Edwards	The MITRE Corporation
Brian Johnson	The MITRE Corporation
Lauren Lusty	The MITRE Corporation
Karri Meldorf	The MITRE Corporation
Julie Snyder	The MITRE Corporation
Lauren Swan	The MITRE Corporation
Anne Townsend	The MITRE Corporation
Jessica Walton	The MITRE Corporation

60 The Technology Partners/Collaborators who participated in this build submitted their capabilities in
61 response to a notice in the Federal Register. Respondents with relevant capabilities or product

62 components were invited to sign a Cooperative Research and Development Agreement (CRADA) with
 63 NIST, allowing them to participate in a consortium to build this example solution. We worked with:

Technology Partner/Collaborator	Build Involvement
Avrio Software (now known as Aerstone)	Avrio SIFT
Cisco Systems	Duo
Dispel	Dispel
FireEye	FireEye Helix
Qcor	Qcor ForceField
PKWARE	PKWARE PKProtect
StrongKey	StrongKey Tellaro
Symantec, a Division of Broadcom	Symantec Web Isolation

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 71 terms “can” and “cannot” indicate a possibility and capability, whether material, physical, or causal.

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96 whether such provisions are included in the relevant transfer documents.

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154 **1 Summary**

155 In our data-driven world, organizations must prioritize cybersecurity and privacy as part of their business
 156 risk management strategy. Specifically, data confidentiality remains a challenge as attacks against an
 157 organization’s data can compromise emails, employee records, financial records, and customer
 158 information—impacting business operations, revenue, and reputation.

159 Confidentiality is officially defined as “preserving authorized restrictions on information access and
 160 disclosure, including means for protecting personal privacy and proprietary information”[1]. Data
 161 confidentiality makes sure that only the right people have access to the right data. Ensuring data
 162 confidentiality should be a priority for any organization regardless of industry. A loss of data
 163 confidentiality can be of great impact to not just the company or organization, but also to the individuals
 164 who have trusted the organization with their data.

165 The National Cybersecurity Center of Excellence (NCCoE) at the National Institute of Standards and
 166 Technology (NIST) developed an example solution to address data security and privacy needs. This
 167 project fits within a larger series of Data Security projects that are organized by the elements of the
 168 Confidentiality, Integrity, Availability (CIA) triad, and the NIST Cybersecurity Framework’s (CSF) Core
 169 Functions: Identify, Protect, Detect, Respond, and Recover.



Note: This project was initiated before the release of the DRAFT NIST CSF 2.0 and thus does not include the newly added GOVERN function. The DRAFT NIST CSF 2.0 defines Govern as “Establish and monitor the organization’s cybersecurity risk management strategy, expectations, and policy”. The govern function cuts across the other CSF functions. Though this document focuses on technical capabilities, it’s intended that those capabilities would support an organizational governance function in managing data confidentiality attack risk.

170 **Figure 1-1 Data Security Project Mapping**

Cybersecurity Framework Functions	Information Security Goals		
	Confidentiality	Integrity	Availability
Identify	1800-28 (you are here)	1800-25	
Protect			
Detect		1800-26	
Respond	1800-29		
Recover		1800-11	

171 The goals of this NIST Cybersecurity Practice Guide are to assist organizations in identifying and
172 protecting their assets and data in order to prepare for and prevent a data confidentiality event. This
173 guide will help organizations:

- 174 • Inventory data storage and data flows
- 175 • Protect against confidentiality attacks against hosts, the network and enterprise components
- 176 • Protect enterprise data at rest, in transit, and in use
- 177 • Configure logging and audit capabilities to meet organizational requirements
- 178 • Provide user access controls to sensitive data
- 179 • Provide user authentication mechanisms for host and network access
- 180 • Enumerate data flows and problematic data actions in line with the NIST privacy framework

181 In addition to the guidance provided in these documents, NIST has many resources available to help
182 organizations to identify and protect data:

- 183 • NIST Special Publication 1800-25, Data Integrity: Identifying and Protecting Assets Against
184 Ransomware and other Destructive Events [2]
- 185 • NIST Special Publication 800-83, Guide to Malware Incident Prevention and Handling for Desktops
186 and Laptops [5]
- 187 • NIST Special Publication 800-46, Guide to Enterprise Telework, Remote Access, and Bring Your Own
188 Device (BYOD) Security [6]
- 189 • NIST Privacy Framework [7]
- 190 • NIST Cybersecurity Framework [8]
- 191 • NIST Interagency Report 8374, Ransomware Risk Management: A Cybersecurity Framework Profile
192 [9]
- 193 • NIST Special Publication 800-160, Developing Cyber-Resilient Systems: A Systems Security
194 Engineering Approach [10]

195 **1.1 Challenge**

196 Fundamentally, data confidentiality is a challenge because all data exists to be accessible by some
197 number of authorized people or systems. Data access only becomes a data breach when that access is
198 by an unauthorized person or system. The quantity and diversity of an organization’s data, the varying
199 methods of data access (on-site versus remote, computer versus mobile device) and the potential for
200 the compromise of valid user credentials all challenge an organization’s ability to maintain the
201 confidentiality of their data. NIST SP 1800-28 focuses on the Identify and Protect Functions of the NIST
202 Cybersecurity Framework and addresses the challenges related to categorizing authorized and
203 unauthorized data access. Once that ontology is developed, this document helps organizations address
204 identifying potential breaches of data confidentiality as well as protecting against the resulting losses.

205 Additional challenges arise when defining what it means to “identify” or “protect” data. In the NCCoE’s
206 previous work on Data Integrity (1800-25[2], 1800-26[3], and 1800-11[4]), it was possible to define
207 recovery as a rollback of the compromised data to a point in time before it was altered. With respect to
208 a loss of data confidentiality, there is no such process by which to “undo” the effects of such a loss—
209 once digital data is in the hands of an unauthorized user, there is no guaranteed method by which to get
210 all copies of the data back. This leaves an organization and the affected individuals with non-technical

211 mitigations for the consequences of the breach (financial, reputational, etc.), as well as the ability of the
212 organization to apply the lessons learned to technical improvements earlier in the timeline to prevent
213 against future breaches.

214 1.2 Solution

215 The NCCoE developed this two-part solution to address considerations for both data security and data
216 privacy to help organizations manage the risk of a data confidentiality attack. The work in 1800-29
217 addresses an organization’s actions during and after a loss of data confidentiality (the remaining NIST
218 CSF Functions of Detect, Respond, and Recover) while this guide’s focus is on the needs prior to a loss of
219 data confidentiality (by focusing on the NIST CSF Functions Identify and Protect). The solution utilizes
220 commercially available tools to provide relevant capabilities such as automated data sensitivity
221 detection, user access controls for data, encryption of potential confidential data, and multifactor
222 authentication, among others.

223 1.3 Benefits

224 Organizations can use this guide to help:

- 225 ▪ Evaluate their data confidentiality concerns
- 226 ▪ Determine whether their data security needs align with the challenges described in these
227 documents
- 228 ▪ Conduct a gap analysis to determine the distance between the organization’s current state and
229 desired state with respect to data confidentiality
- 230 ▪ Perform an assessment of the feasibility of implementing any number of these solutions
- 231 ▪ Determine a business continuity analysis to identify potential impacts on business operations as
232 a result of a loss of data confidentiality.

233 2 How to Use This Guide

234 This NIST Cybersecurity Practice Guide demonstrates a standards-based reference design and provides
235 users with the information they need to replicate the data confidentiality capabilities described in this
236 document. This reference design is modular and can be deployed in whole or in part.

237 This guide contains three volumes:

- 238 ▪ NIST SP 1800-28A: Executive Summary
- 239 ▪ NIST SP 1800-28B: Approach, Architecture, and Security Characteristics – what we built and why
240 (you are here)
- 241 ▪ NIST SP 1800-28C: How-To Guides – instructions for building the example solution

242 Depending on your role in your organization, you might use this guide in different ways:

243 **Business decision makers, including chief security and technology officers,** will be interested in the
244 *Executive Summary, NIST SP 1800-28A*, which describes the following topics:

- 245 ▪ challenges that enterprises face in identifying vulnerable assets and protecting them from data
- 246 breaches
- 247 ▪ example solution built at the NCCoE
- 248 ▪ benefits of adopting the example solution

249 **Technology or security program managers** who are concerned with how to identify, understand, assess,
250 and mitigate risk will be interested in this part of the guide, *NIST SP 1800-28B*, which describes what we
251 did and why. The following sections will be of particular interest:

- 252 ▪ Section 3.5, [Risk Assessment](#), provides a description of the risk analysis we performed
- 253 ▪ Section 3.6, [Security Control Map](#), maps the security characteristics of this example solution to
- 254 cybersecurity standards and best practices

255 You might share the *Executive Summary, NIST SP 1800-28A*, with your leadership team members to help
256 them understand the importance of adopting standards-based solutions to protecting against losses in
257 data confidentiality.

258 **IT professionals** who want to implement an approach like this will find the whole practice guide useful.
259 You can use the how-to portion of the guide, *NIST SP 1800-28C*, to replicate all or parts of the build
260 created in our lab. The how-to portion of the guide provides specific product installation, configuration,
261 and integration instructions for implementing the example solution. We do not re-create the product
262 manufacturers' documentation, which is generally widely available. Rather, we show how we
263 incorporated the products together in our environment to create an example solution.

264 This guide assumes that IT professionals have experience implementing security products within the
265 enterprise. While we have used a suite of commercial products to address this challenge, this guide does
266 not endorse these particular products. Your organization can adopt this solution or one that adheres to
267 these guidelines in whole, or you can use this guide as a starting point for tailoring and implementing
268 parts of a security architecture that protects against data breaches. Your organization's security experts
269 should identify the products that will best integrate with your existing tools and IT system infrastructure.
270 We hope that you will seek products that are congruent with applicable standards and best practices.
271 Section 3.6, [Technologies](#), lists the products we used and maps them to the cybersecurity and privacy
272 controls provided by this reference solution.

273 A NIST Cybersecurity Practice Guide does not describe "the" solution, but a possible solution. This is a
274 draft guide. We seek feedback on its contents and welcome your input. Comments, suggestions, and
275 success stories will improve subsequent versions of this guide. Please contribute your thoughts to [ds-](mailto:ds-nccoe@nist.gov)
276 [nccoe@nist.gov](mailto:ds-nccoe@nist.gov).

277 **2.1 Typographic Conventions**

278 The following table presents typographic conventions used in this volume.

Typeface/Symbol	Meaning	Example
<i>Italics</i>	file names and path names; references to documents that are not hyperlinks; new terms; and placeholders	For language use and style guidance, see the NCCoE Style Guide.
Bold	names of menus, options, command buttons, and fields	Choose File > Edit .
Monospace	command-line input, onscreen computer output, sample code examples, and status codes	<code>mkdir</code>
Monospace Bold	command-line user input contrasted with computer output	<code>service sshd start</code>
blue text	link to other parts of the document, a web URL (uniform resource locator), or an email address	All publications from NIST's NCCoE are available at https://www.nccoe.nist.gov .

279 3 Approach

280 The NCCoE is developing a set of data confidentiality projects mapped to the five Functions of the NIST
 281 Cybersecurity Framework Core. This project centers on identifying and protecting vulnerable data from
 282 attack. Our commercial collaboration partners have volunteered to provide the products that provide
 283 this example solution for the problems raised in each of our use cases. Through this collaboration, our
 284 goal is to create actionable recommendations for organizations and individuals trying to solve data
 285 confidentiality issues.

286 3.1 Audience

287 The architecture of this project and accompanying documentation targets three distinct groups of
 288 readers. The first is those personally managing, implementing, installing and configuring IT security
 289 solutions for their organization. The walkthroughs of installation and configuration of the chosen
 290 commercial products, as well as any of our notes on lessons learned, work to ease the challenge of
 291 implementing security best practices. This guide also serves as a starting point for those addressing
 292 these security issues for the first time, and a reference for experienced admins who want to do better.

293 The second group are those tasked with establishing broader security policies for their organizations.
 294 Reviewing the threats each organization needs to account for and their potential solutions allows for
 295 more robust and efficient security policy to be generated with greater ease.

296 The final group are those individuals responsible for the legal ramifications of breaches of
 297 confidentiality. Many organizations have legal obligations to take steps to proactively protect the
 298 personal data or personally identifiable information (PII) of individuals they process. The ramifications
 299 for failing to adequately protect PII can have severe consequences for both individuals and follow on
 300 consequences for the organizations as a whole.

301 This guide will allow potential adopters to assess the feasibility of implementing data confidentiality best
302 practices within the IT systems of their own organization.

303 **3.2 Scope**

304 This document provides guidance on identifying potentially sensitive data and protecting against a loss
305 of data confidentiality. Refer to [Figure 1-1](#) to understand how this document fits within the larger set of
306 NCCoE Data Security projects, as organized by the CIA triad and the functions of the NIST Cybersecurity
307 Framework Core.

308 **3.3 Assumptions**

309 The technical solution developed at the NCCoE and represented in this guide does not incorporate the
310 non-technical aspects of managing the confidentiality of an organization's data. The non-technical
311 components could include (but are not limited to):

- 312 • applicable legal requirements based on pertinent jurisdictions
- 313 • corporate or other superseding policies relevant to confidentiality and privacy
- 314 • standard operating procedures in the event of a loss of data confidentiality
- 315 • public relations strategies

316 This project is guided by the following assumptions:

- 317 • The solution was developed in a laboratory environment and is limited in the size and scale of
318 data.
- 319 • Only a subset of products relevant to data confidentiality are included in this project, as such
320 organizations should consider the guiding principles of this document when evaluating their
321 organization's needs against the product landscape at the time of their IT implementation.

322 **3.4 Privacy Considerations**

323 Because privacy risks may arise as a result of a loss of confidentiality of data, this guide includes privacy
324 considerations. This section gives a primer for why privacy is important to protect, the relationship
325 between privacy and cybersecurity risk, as well as NIST's approach to privacy risk assessment.

326 In today's digital landscape, consumers conduct much of their lives on the internet. Data processing,
327 which includes any operations taken with data, including the collection, usage, storage, and sharing of
328 data by organizations, can result in privacy problems for individuals. Privacy risks can evolve with
329 changes in technology and associated data processing. How organizations treat privacy has a direct
330 bearing on their perceived trustworthiness. Recognizing the evolving privacy impacts of technology on
331 individuals, governments across the globe are working to address their concerns through new or
332 updated laws and regulations.

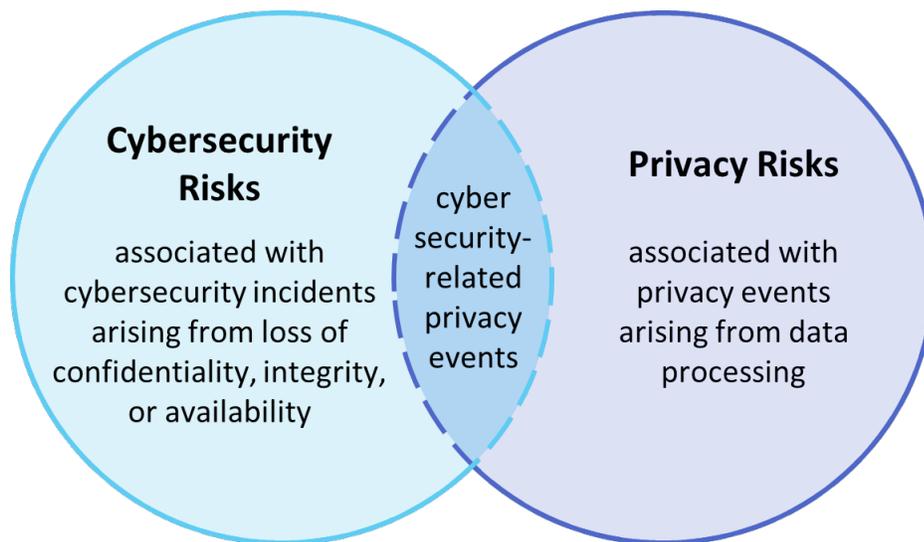
333 Following an open and transparent development process, NIST published the NIST Privacy Framework,
334 Version 1.0 to help organizations better identify and manage their privacy risks, build trust with
335 customers and partners, and meet their compliance obligations. The Privacy Framework Core provides
336 privacy outcomes that organizations may wish to achieve as part of a privacy risk management program.

337 The Privacy Framework also discusses privacy engineering objectives that can be used to help
 338 organizations prioritize their privacy risk management activities. The privacy engineering objectives are:

- 339 • Predictability: Enabling reliable assumptions by individuals, owners, and operators about data
 340 and their processing by a system
- 341 • Manageability: Providing the capability for granular administration of data, including collection,
 342 alteration, deletion, and selective disclosure
- 343 • Disassociability: Enabling the processing of data or events without association to individuals or
 344 devices beyond the operational requirements of the system

345 It is important for individuals and organizations to understand the relationship between cybersecurity
 346 and privacy. As noted in Section 1.2.1 of the *NIST Privacy Framework* [8], having a general understanding
 347 of the different origins of cybersecurity and privacy risks is important for determining the most effective
 348 solutions to address the risks. Figure 3-1 illustrates this relationship, showing that some privacy risks
 349 arise from cybersecurity risks, and some are unrelated to cybersecurity risks.

350 **Figure 3-1 Cybersecurity and Privacy Risk Relationship**



351 Though a data confidentiality breach may lead to privacy problems for individuals, it is important to note
 352 that privacy risks can arise without a cybersecurity incident. For example, an organization might process
 353 data in ways that violates an individual’s privacy without that data having been breached or
 354 compromised through a security incident. This type of issue can occur under a variety of scenarios, such
 355 as when data is stored for extended periods, beyond the need for which the information was initially
 356 collected.

357 Privacy risks arise from privacy events—the occurrence or potential occurrence of problematic data
 358 actions. The NIST Privacy Framework defines problematic data actions as data actions that may cause an
 359 adverse effect for individuals. Problematic data actions might arise by data processing simply for mission
 360 or business purposes. Privacy risk is the likelihood that individuals will experience problems resulting
 361 from data processing, and the impact should they occur. [16] As reflected in the overlap of Figure 31,
 362 analyzing these risks in parallel with cybersecurity risks can help organizations understand the full

363 consequences of impacts of data confidentiality breaches. Section 5.3 demonstrates scenarios where
364 privacy risks may arise and potential mitigations.

365 Based on the reference architecture, this build considered the data actions that potentially cause
366 problematic data actions.

367 3.5 Risk Assessment

368 NIST SP 800-30 Revision 1, *Guide for Conducting Risk Assessments*, states that risk is “a measure of the
369 extent to which an entity is threatened by a potential circumstance or event, and typically a function of:
370 (i) the adverse impacts that would arise if the circumstance or event occurs; and (ii) the likelihood of
371 occurrence.” The guide further defines risk assessment as “the process of identifying, estimating, and
372 prioritizing risks to organizational operations (including mission, functions, image, reputation),
373 organizational assets, individuals, other organizations, and the Nation, resulting from the operation of
374 an information system. Part of risk management incorporates threat and vulnerability analyses, and
375 considers mitigations provided by security controls planned or in place.”

376 The NCCoE recommends that any discussion of risk management, particularly at the enterprise level,
377 begins with a comprehensive review of NIST SP 800-37 Revision 2, *Risk Management Framework for*
378 *Information Systems and Organizations* [12]—material that is available to the public. The Risk
379 Management Framework (RMF) [13] guidance proved to be invaluable in giving us a baseline to assess
380 risks, from which we developed the project, the security characteristics of the build, and this guide.

381 3.5.1 Security Risk Assessment

382 Security risk assessments often discuss the consideration of threats to an information system. NIST SP
383 800-30 Revision 1 defines a threat as “[a]ny circumstance or event with the potential to adversely
384 impact organizational operations and assets, individuals, other organizations, or the Nation through an
385 information system via unauthorized access, destruction, disclosure, or modification of information,
386 and/or denial of service”. Threats are actions that may compromise a system’s confidentiality, integrity,
387 or availability[11]. Threats evolve, and an organization needs to perform its own analysis when
388 evaluating threats and risks that the organization faces.

389 The following threats were considered during the development of the data confidentiality solution:

- 390 • exfiltration by malicious outsider actor
- 391 • exfiltration by malicious internal actor (privilege misuse)
- 392 • ransomware with threat to leak data
- 393 • non-malicious insider actor (accidental email)
- 394 • misplaced hardware

395 For a threat to be realized, a system, process or person must be vulnerable to a threat action. A
396 vulnerability is a deficiency or weakness that a threat source may exploit, resulting in a threat event.
397 Vulnerabilities may exist in a broader context. That is, they may be found in organizational governance
398 structures, external relationships, and mission/business processes.

399 Organizations should consider impact if a data confidentiality breach occurs including potential decline
400 in organizational trust and credibility affecting employees, customers, partners, stakeholders as well as
401 financial impacts due to loss of proprietary or other sensitive information.

402 3.5.2 Privacy Risk Assessment

403 This build also incorporates privacy as part of the build risk assessment. It is important for organizations
404 to address privacy risk as part of a comprehensive risk management process. The build utilized the NIST
405 Privacy Framework [7] and Privacy Risk Assessment Methodology (PRAM) [14] to identify and address
406 privacy risks.

407 As part of identifying privacy risks in this build, problematic data actions were correlated to observed
408 privacy risks. In many cases, the security capabilities in this build will help mitigate privacy risks, but
409 organizations should use caution to implement these capabilities in a way that does not introduce new
410 privacy risks.

411 Section 5.3 discusses problematic data action and privacy considerations for this build.

412 3.6 Technologies

413 Table 3-1 Products and Technologies lists the technologies used in this project and provides a mapping
414 among the generic application term, the specific product used, and the security control(s) that the
415 product provides. Refer to Table 6-1 Security Control Map for an explanation of the NIST Cybersecurity
416 Framework Subcategory identifiers. Table 3-1 also provides the Privacy Framework Subcategory
417 identifiers, and these are explained in [Appendix E](#).

418 Table 3-1 Products and Technologies

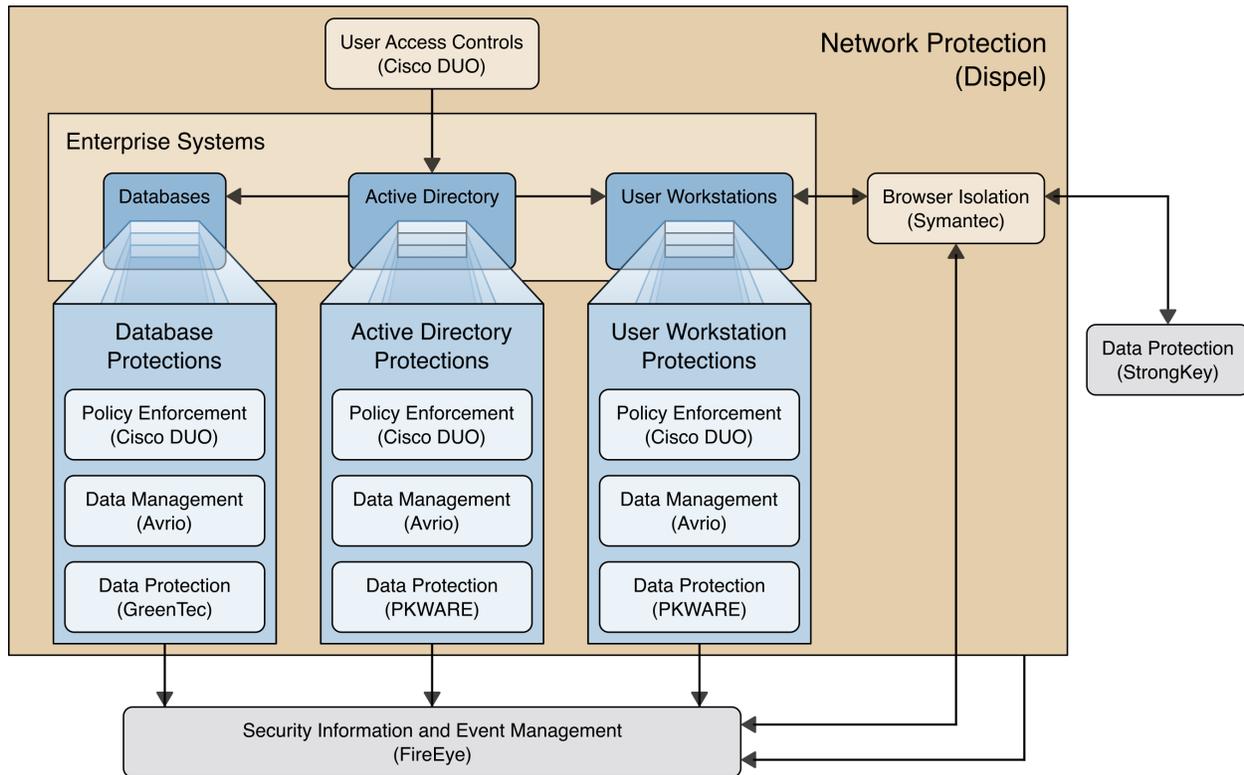
Component	Product	Capability	NIST Cybersecurity Framework Subcategories	NIST Privacy Framework Subcategories
Data Management	Avrio SIFT v1.0.5.R5	<ul style="list-style-type: none"> Discovers, tags, and protects sensitive files across the network 	ID.AM-2, PR.DS-1, PR.DS-3	ID.IM-P1, PR.DS-P1, PR.DS-P3
Data Protection	Qcor Forcefield v1.9h	<ul style="list-style-type: none"> Protects data at-rest from unauthorized access and malicious modification 	PR.DS-1	PR.DS-P1
	PKWARE PKProtect v16.40.0010	<ul style="list-style-type: none"> Provides data encryption at-rest and in-transit 	PR.DS-1, PR.DS-2	PR.DS-P1, PR.DS-P2
	StrongKey Tellaro	<ul style="list-style-type: none"> Provides a Web API (application programming interface) for encryption and tokenization, key management, and strong authentication 	PR.AC-7, PR.DS-2	PR.AC-P6, PR.DS-P2
User Access Controls	Cisco Duo	<ul style="list-style-type: none"> Provides multi-factor authentication 	PR.AC-1, PR.AC-4, PR.AC-7	PR.AC-P1, PR.AC-P4, PR.AC-P6
Browser Isolation	Symantec Web Isolation	<ul style="list-style-type: none"> Provides isolation of web browsers to protect from risky traffic Protects from malware and phishing threats Provides a privacy toggle that allows for user browsing data to be anonymized. Provides a login banner to inform individuals of data collection practices with web browsing 	PR.AC-5, PR.DS-2	PR.AC-P5, PR.DS-P2, CT.DP-P2, CM.AW-P3
Policy Enforcement	Cisco Duo	<ul style="list-style-type: none"> Provides policy control on a global or per-application basis 	PR.IP-5	PR.PO-P4

Component	Product	Capability	NIST Cybersecurity Framework Subcategories	NIST Privacy Framework Subcategories
Logging	FireEye Helix	<ul style="list-style-type: none"> Provides a baseline for normal enterprise operations Provides logs and enables incident response 	ID.RA-1, ID.RA-2, ID.RA-3, PR.PT-1	CT.DM-P8
Network Protection	Dispel	<ul style="list-style-type: none"> Provides remote access to network 	PR.AC-3, PR.AC-5	PR.AC-P3, PR.AC-P5

419 4 Architecture

420 This section presents the high-level architecture and a set of capabilities used in our data confidentiality
421 reference design that identifies and protects assets from unauthorized access and disclosure.

422 **Figure 4-1 High Level Architecture**



423 Each of the capabilities implemented plays a role in mitigating data confidentiality attacks:

- 424 • **Data Management** allows discovery and tracking of files throughout the enterprise.
- 425 • **Data Protection** involves encryption and protection against disclosure of sensitive files.
- 426 • **User Access Controls** allows organizations to enforce access control policies, ensuring that only
427 authorized users have access to sensitive files.
- 428 • **Browser Isolation** protects endpoints in the organization from malicious web-based malware by
429 sandboxing and containing executables downloaded from the internet.
- 430 • **Policy Enforcement** ensures that endpoints in the organization conform to specified security
431 policies, which can include certificate verification, installed programs, and machine posture.
- 432 • **Logging** creates a baseline of a normal enterprise activity for comparison in the event of a data
433 confidentiality event.
- 434 • **Network Protection** ensures that hosts on the network only communicate in allowed ways,
435 preventing side-channel attacks and attacks that rely on direct communication between hosts.
436 Furthermore, it protects against potentially malicious hosts joining or observing traffic (encrypted or
437 decrypted) traversing the network.

438 These capabilities work together to provide the functions Identify and Protect for the reference
439 architecture. The data management capability provides data inventory and asset management for files
440 in the enterprise; helps identify potentially sensitive files; and works with the data protection capability
441 to ensure potentially sensitive files are properly protected in the event of a breach. Because
442 organizations can be large and new sensitive files may be created daily, it is important to have the
443 capability to automate identification and protection of files at least partially. The data protection
444 capability and user access controls prevent data from being read by unauthorized parties. By ensuring
445 that only the correct people have access to data, and that data is properly encrypted and stored, it
446 becomes more difficult for adversaries to steal and disclose sensitive data.

447 The policy enforcement, network protection, and browser isolation capabilities work together to protect
448 endpoints such as laptops and desktops against common attack vectors. Malicious websites distributing
449 malware first pass through the browser isolation capability, which sandboxes webpages to ensure that
450 malware downloaded via malicious webpage cannot spread to the user or enterprise's system. Network
451 segmentation uses network layer policies to group endpoints into segments based on business needs. If
452 an endpoint is infected, network segmentation can limit impact by preventing malware from spreading
453 between segments. Policy enforcement ensures that systems remain up to date with organizationally
454 defined security policies. All of these functions feed into logging capabilities and provide organizations
455 with an understanding of their baseline of normal activity. These logs inform the organization of its
456 security posture before an event, so that the organization can adjust its policies as new information
457 about threats becomes available and take appropriate action.

458 **5 Security & Privacy Characteristic Analysis**

459 The following section is intended to help organizations understand the extent to which the project
460 meets its objective of demonstrating technologies and capabilities to help organizations mitigate data
461 confidentiality risk. To support this, we developed several scenarios which organizations may consider
462 when conducting their security and privacy risk analysis. For each scenario we discuss how our
463 architecture might help mitigate or limit security and privacy risks.

464 **5.1 Assumptions and Limitations**

465 The following analysis has the following limitations:

- 466 ▪ It is neither a comprehensive test of all security and privacy components, nor a red-team
467 exercise.
- 468 ▪ It cannot identify all weaknesses or risks.
- 469 ▪ It does not include the lab infrastructure. It is assumed that devices are hardened. Testing these
470 devices would reveal only weaknesses in implementation that would not be relevant to those
471 adopting this reference architecture.

472 **5.2 Security Scenarios**

473 Our security evaluation involved assessing how well the reference design addresses the security
474 characteristics that it was intended to support. Each scenario lays out a potential cybersecurity event
475 and discusses the responsibilities of an organization with respect to each event, and how the security

476 capabilities of our architecture would help an organization address the Cybersecurity Framework
477 Functions of **Identify** and **Protect** for that event.

478 Below is a list of the scenarios created to test the security capabilities of this architecture.

479 NOTE: The below scenarios map to the DRAFT NIST CSF 2.0. For a mapping to the NIST CSF 1.1 please
480 see Security Control Map in Appendix D.

481 5.2.1 Exfiltration of Encrypted Data

482 Table 5-1 Exfiltration of Encrypted Data Security Scenario

Description	An organization has unknowingly acquired a compromised machine from an outside source and has attached the machine to its trusted network. This machine periodically scans a certain part of the filesystem, which it has deemed to be potentially sensitive, and encrypts and uploads the contents to a malicious web host. Because the machine was assumed to be trusted due to human error, the delivery of this malware into the system is difficult to detect; it must be detected and stopped after it has already started running.
Associated DRAFT CSF 2.0 Subcategories	ID.AM-01, ID.AM-02, ID.AM-03, ID.AM-5, ID.RA-5, PR.AA-01, PR.AA-02, PR.AA-05, PR.DS-01, PR.DS-02, PR.DS-10, PR.PS-01, PR.PS-04
Organizational Response	In this scenario, the organization accepts an infected machine onto its network. As an example, this could be hardware ordered from a third-party vendor, potentially having been refurbished or modified before delivery to the organization. Because the organization connects the machine directly to the network, the acquisition of the malware happens immediately and without warning. It falls to the organization to protect sensitive data from this breach, as well as be able to identify the traffic generated by the malware as anomalous.
Identify	The Data Management capability is used to identify new sensitive data when it is created and track it throughout the organization. The results of this capability are used to inform protection and response capabilities about which data is at risk of targeting and the impact to the enterprise in the event of compromise.
Protect	The Data Protection capability provides encryption for sensitive data which has been identified as important, protecting it from unauthorized access in the event of an exfiltration attack. Another important aspect of the Protect function is the documentation of audit logs, with respect to sensitive data. The Logging capability provides a baseline for normal enterprise activity. This baseline can be used as a comparison point in the Detect phase to discover anomalies in network traffic and lead to the discovery of malicious exfiltration.

483

5.2.2 Spear Phishing Campaign

484 **Table 5-2 Spear Phishing Campaign Security Scenario**

Description	An unknown user has successfully launched a spear phishing attack, and in the process retrieved an authorized user’s login and password. This user has access to several of the organization’s databases, allowing them to both view and manipulate the data contained within. This exposes proprietary data to theft and manipulation/deletion.
Associated DRAFT CSF 2.0 Subcategories	PR.AA-01, PR.AA-02, PR.AA-03, PR.DS-01, PR.DS-02, PR.PS-01, PR.PS-04, DE.CM-09
Organizational Response	In this scenario, someone at the organization with privileged credentials has had their credentials compromised through a spear phishing email. The user may report this themselves if they retroactively realize it was a phishing attack, or they may not. The organization will need to deal with a privileged user account with access to the database being used by a malicious actor and is responsible for protecting assets from the compromised account.
Identify	Though identifying assets is an important function, in this scenario we are specifically focusing on the ability of a compromised user to access an in-use database, and do not have a specific need to identify the database as part of the scenario’s resolution, since the target is known.
Protect	<p>The Data Protection capability provides write-protection against alteration or deletion of saved data, as well as protection against reading the data through encryption of data-in-use.</p> <p>Another important aspect of the Protect function is the management of access permissions. The User Access Controls capability allows the database to be protected by a second layer of authentication separate from the user’s username and password. In the event of compromised credentials, the database is less likely to be impacted if two factors of authentication are required.</p> <p>Furthermore, acquisition of user credentials does not necessarily imply that a user’s physical system has been stolen. Policy Enforcement can take advantage of this by forcing computers connecting to organizational resources to be trusted via certificate or meet other requirements to ensure that a username and password is not enough to compromise critical resources.</p>

485

5.2.3 Ransomware

486 **Table 5-3 Ransomware Security Scenario**

Description	An employee of the company makes a mistake while entering the URL of their company’s email provider. This mistake takes them to an identical login page, but it is hosted by a malicious actor. When they enter their credentials on the login page, the page records their credentials, and forwards them to the actual login page, as if the credentials were
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	<p>mistyped. The malicious actor later uses these credentials to login as the employee. They download and run a malicious ransomware executable as the user. The ransomware executable uploads sensitive files to the malicious host website, which displays a notice that unless a ransom is paid, the sensitive files will remain publicly visible.</p>
Associated DRAFT CSF 2.0 Subcategories	ID.AM-01, ID.AM-02, ID.AM-03, ID.AM-5, ID.RA-5, PR.AA-01, PR.AA-02, PR.AA-03, PR.AA-05, PR.DS-01, PR.DS-02, PR.DS-10, PR.IR-01, PR.PS-01, PR.PS-04
Organizational Response	In this scenario, someone at the organization with privileged credentials has had their credentials compromised through a malicious webpage disguised as the organization’s email provider. The user may or may not report the attack, though there may be clues as to its existence - a user with account troubles and traffic going to a domain name very similar to the organization’s domain might be enough to send up red flags if noticed. Regardless, the organization will need to deal with a privileged user account being used to download malware and hold the confidentiality of sensitive files ransom.
Identify	The Data Management capability is used to identify new sensitive data when it is created and track it throughout the organization. The results of this capability are used to inform protection and response capabilities about which data is at risk of targeting and the impact to the enterprise in the event of compromise.
Protect	<p>The Data Protection capability provides encryption for sensitive data, protecting it from unauthorized access in the event of an exfiltration attack. Even if the data is stolen and released, encryption prevents the data from being used or read.</p> <p>Another important component of the Protect function is the documentation of audit logs, with respect to sensitive data. The Logging capability provides a baseline for normal enterprise activity. This baseline can be used as a comparison point in the Detect phase to discover anomalies in network traffic and user behavior, potentially allowing for the detection of a malicious actor accessing the user’s workstation outside of normal hours.</p> <p>Browser Isolation, in tandem with Network Protection, will prevent downloads of malicious files from websites and unknown ports, limiting the attacker’s ability to acquire their ransomware program after the system has been compromised. While the ability to download malicious programs onto the workstation may not completely stop determined attackers, it increases the difficulty and time required for the attack, allowing more time for Detection and Respond activities by the defending organization.</p>

487

5.2.4 Accidental Email

488 **Table 5-4 Accidental Email Security Scenario**

Description	A user of the organization accidentally cc's an individual on an email. This email has an attachment containing proprietary information which the cc'd individual is not cleared for. The individual copied on the email is considered a disgruntled employee, and when he sees this email, immediately downloads and saves these files.
Associated DRAFT CSF 2.0 Subcategories	ID.AM-01, ID.AM-02, ID.AM-03, ID.AM-5, ID.RA-5, PR.AA-01, PR.AA-02, PR.AA-03, PR.AA-05, PR.DS-01, PR.DS-02, PR.DS-10, PR.IR-01, PR.PS-04
Organizational Response	In the event of an accidental information leak via email, it is not unlikely that the event will be reported. Since there are multiple parties involved who are not malicious, it is possible that one of them will report the incident. Regardless of whether it is reported, however, the organization should be able to track the transfer of sensitive data to the unauthorized employee's system, and also prevent that employee from reading it.
Identify	The Data Management capability is used to identify new sensitive data when it is created and track it throughout the organization. The results of this capability are used to inform protection and response capabilities about which data is at risk and the impact to the enterprise in the event of an information leak.
Protect	The Data Protection capability provides encryption for sensitive information, protecting it from unauthorized access even if it is accidentally sent to unauthorized users. Another important component of the Protect function is documentation of audit logs, with respect to sensitive data. The Logging capability provides a baseline for normal enterprise activity. This baseline can be used as a comparison point in the Detect phase for reporting on data which has been transferred onto the systems of unauthorized users.

489

5.2.5 Lost Laptop

490 **Table 5-5 Lost Laptop Security Scenario**

Description	A user has lost their work laptop, which contains proprietary information. It is unknown if the laptop was targeted for its data and access credentials by a malicious actor, or if the incident was an unfortunate accident. For the purposes of this scenario, we assume the user of the laptop has reported the missing system on their own.
Associated DRAFT CSF 2.0 Subcategories	ID.AM-01, ID.AM-02, ID.AM-05, ID.AM-07, PR.AA-01, PR.AA-03, PR.DS-01, PR.DS-09, PR.PS-03
Organizational Response	In the event of a lost laptop, it is likely that the loss will be reported by the user, as the user will directly lose their ability to work. Although some aspects of this event are easier because of the user's knowledge of the system, it is important for the organization to determine the data that was on the laptop, the security posture of the laptop, and the access the laptop

	provided to the organization's network, so that the loss can be accurately assessed, and further data loss can be prevented.
Identify	<p>The Data Management capability is used to identify new sensitive data when it is created and track it throughout the organization. The results of this capability are used to inform protection and response capabilities about which data is at risk and the impact to the enterprise in the event of a compromise.</p> <p>The Policy Enforcement capability can be used to force computers connecting to organizational resources to meet requirements regarding which programs are installed. While this capability typically falls under the Protect function, knowing the security posture of assets in the enterprise is an important Identify function. When policy enforcement is used to ensure the presence of encryption capabilities, for example, the enterprise has some assurance that data on the workstation has not been compromised.</p>
Protect	<p>The Data Protection capability provides encryption for the laptop and prevents sensitive data from being read.</p> <p>Another important aspect of the Protect function is the management of access permissions. The User Access Controls capability allows the network to be protected by two layers of authentication. Although the laptop may be compromised, requiring user account credentials as well as a second factor of authentication protects the network from further compromise.</p> <p>Policy Enforcement can be used to force computers connecting to organizational resources to meet requirements regarding which programs are installed, which helps to ensure that lost or stolen machines will have adequate data protection and user access control in place to prevent the loss of data in the event of a lost or stolen laptop.</p>

491 5.2.6 Privilege Misuse

492 Table 5-6 Privilege Misuse Security Scenario

Description	A malicious insider navigates to one of the organization's shared drives, and finds sensitive information stored there. Looking to sell this information to competitors, the insider copies the information to his personal USB (universal series bus) drive. The insider also prints these files.
Associated DRAFT CSF 2.0 Subcategories	ID.AM-01, ID.AM-02, ID.AM-05, ID.AM-07, ID.RA-03, PR.AA-03, PR.AA-05, PR.AA-06, PR.DS-01, PR.DS-02, PR.DS-09, PR.PS-04, PR.IR-01
Organizational Response	It is unlikely that a malicious insider will advertise their misdoings; it falls to the organization to discover the insider behavior and protect assets from them. Through proper access control and encryption of sensitive files, organizations can hinder the insider's attempt to exfiltrate useful data. It is unlikely that an organization will be able to completely stop a determined insider through technical means; however, organizations should use the

	technical capabilities they have to limit the exfiltration, while also gathering information about the extent of the loss to aid in the pursuit of legal resolutions to the incident.
Identify	The Data Management capability is used to identify new sensitive data when it is created and track it throughout the organization. The results of this capability are used to inform protection and response capabilities about which data is at risk and the impact to the enterprise in the event of a compromise. In the event of a malicious insider attempting to exfiltrate data, it is important to know which data was accessible on the machines accessed by the insider, as well as the sensitivity levels of the affected data.
Protect	The Data Protection capability provides encryption for sensitive data , protecting it from unauthorized access. While a malicious insider may be able to decrypt data relevant to their work role, irrelevant data which is encrypted and managed properly will be significantly less useful to the insider. Another important capability within the Protect Function is the management of access permissions. The User Access Controls can prevent unauthorized users from accessing sensitive files in the first place, preventing copying and printing functionality. While user access controls and data protection ensure that the user only has access to some data, ultimately, malicious insiders tend to have some level of access to data due to their role in the organization. Logging provides a baseline for normal enterprise activity. This baseline can be used as a comparison point in the Detect phase for reporting on data which has been exfiltrated from the organization. In the event of exfiltration by a malicious insider, logs can help determine what data was accessed and printed and can aid the organization in recovering from the exfiltration, potentially in non-technical ways, such as through the legal system or law enforcement.

493

5.2.7 Eavesdropping

494

Table 5-7 Eavesdropping Security Scenario

Description	A malicious outsider has gained access to the network traffic of the organization. They possess the capability to intercept and hijack internal communications via man-in-the-middle attack. A user begins uploading a sensitive proposal for a new project. The malicious outsider is able to intercept and view these files.
Associated DRAFT CSF 2.0 Subcategories	ID.AM-01, ID.AM-03, ID.AM-07, PR.AA-05, PR.AA-06, PR.DS-01, PR.DS-02, PR.PS-04, PR.IR-01
Organizational Response	In this scenario, an organization will likely be able to see the introduction of a new device on the network. In this example, a user’s sensitive upload is stolen while it is in transit. The user may see warnings about HTTPS or invalid certificates due to the nature of the attack, and the organization

	may notice anomalous traffic going through the new device on the network. The organization is responsible for identifying the new device as malicious, protecting data intercepted by it through encryption, and mitigating its ability to communicate with trusted enterprise machines.
Identify	The Data Management capability is used to identify new sensitive data when it is created and track it throughout the organization. The results of this capability are used to inform protection and response capabilities about which data is at risk and the impact to the enterprise. In this scenario, a new project proposal is created - the data management capability is used to identify the creation of new sensitive data and track it throughout the enterprise.
Protect	The Data Protection capability provides encryption for sensitive data, protecting it from unauthorized access. While a malicious third party on the network may be able to intercept the data in transit, encryption prevents the third party from being able to read the intercepted data.

Another important component of the Protect Function is the documentation of audit logs, with respect to sensitive data. The Logging capability provides a baseline for normal enterprise activity. This baseline can be used as a comparison point in the Detect phase for noticing anomalous network activity, such as a malicious host on the network acting as a proxy between two systems.

Network Protection is also an important capability for protecting network traffic from malicious adversaries. Using network segmentation, zero trust, and moving target defense capabilities, unrecognized devices can be prevented from identifying, reconnoitering, and accessing the network or communicating with trusted hosts.

495 5.3 Privacy Scenarios

496 The following section describes scenarios an organization may consider when conducting their privacy
 497 risk assessment. Based on the reference architecture used in this project each scenario is examined for
 498 data actions that give rise to potential privacy problems for individuals. Each table documents
 499 problematic data actions taken from the NIST Catalogue of Problematic Data Actions and Problems [16],
 500 and lists privacy mitigations mapped to the NIST Privacy Framework [7]. For the privacy risks analyzed,
 501 consideration was given to how the data is processed. The specific privacy risks found within the
 502 scenarios are derived from the architecture components and the data flows used in this build, but to the
 503 extent possible, generalized for organizations using similar components and capabilities.

504 Organizations may collect information affecting privacy when implementing cybersecurity or privacy-
 505 based controls. For example, an organization might implement multi-factor authentication (MFA) using
 506 information such as mobile phone number. Even though collecting this information helps to protect
 507 systems and data by supporting capabilities like non-repudiation and system auditing, it may also
 508 generate privacy risks.

509 When implementing cybersecurity or privacy-based controls, organizations should consider the benefit a
510 user realizes, both from use of a service and securing that service before processing information
511 affecting privacy. This benefit can be weighed against the risk posed to both individuals and the
512 organization should a privacy event occur.

513 For example, using MFA mentioned above, users may feel compelled to provide information affecting
514 privacy, such as their personal phone number for SMS (short messaging service) authentication, to gain
515 access to systems or services. However, if the user is accessing publicly available information, the risk of
516 the misuse of information from collecting personal phone numbers may be greater than the security
517 benefit for protecting the low-sensitivity information. Additionally, if given the option, users may elect
518 to use alternative authentication methods that are less privacy-invasive, such as using a work phone
519 number over a personal number or a hardware MFA authenticator over SMS authentication. The NIST
520 Privacy Risk Assessment Methodology (PRAM) refers to this problematic data action, where the user is
521 compelled to provide information disproportionate to the purpose or outcome of the transaction, as
522 induced disclosure.

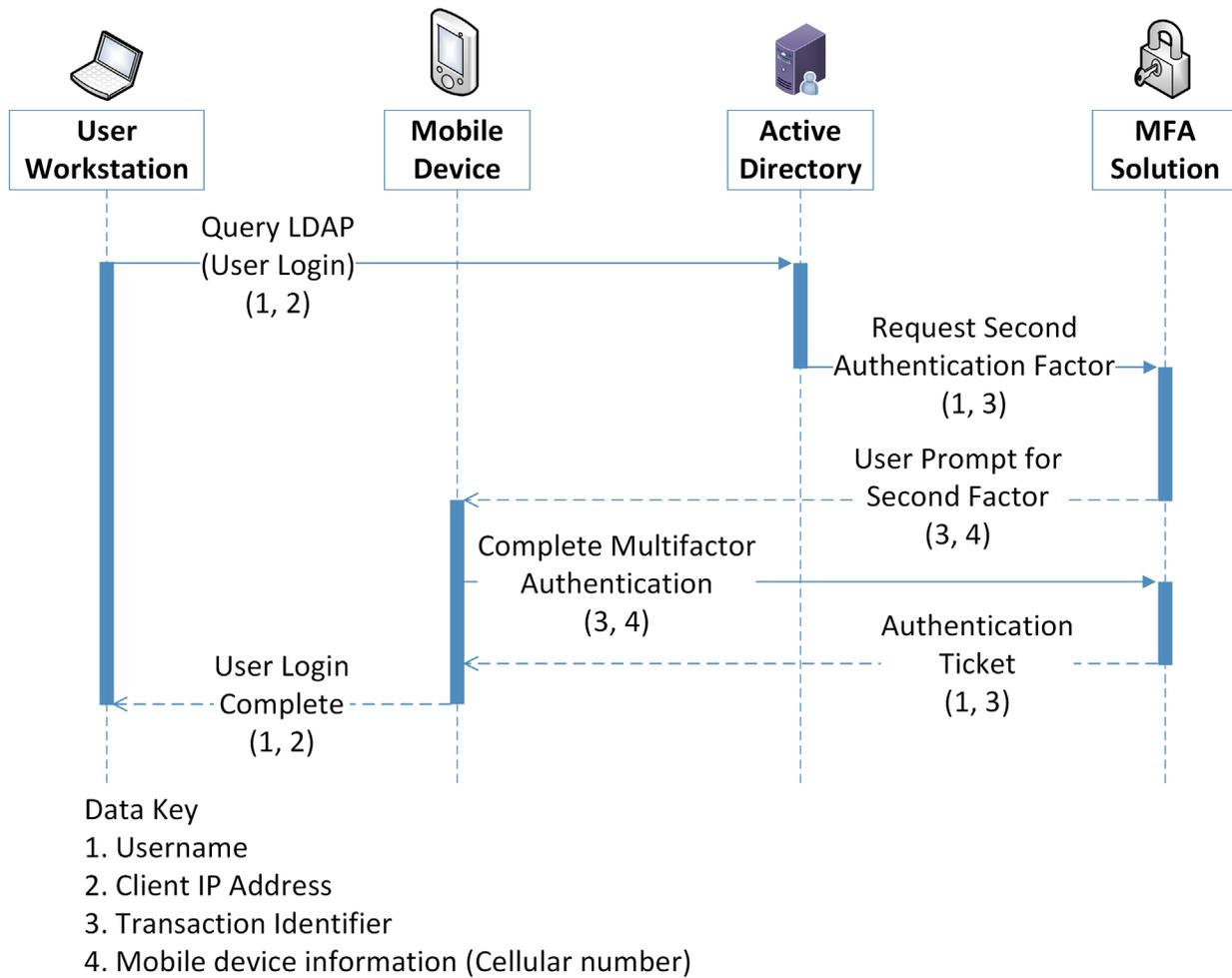
523 Organizations should consider these types of risks as they design and implement systems. As
524 demonstrated in the scenarios below, risk mitigations should be implemented within the design to limit
525 privacy risks. These privacy risk mitigations might include the following, among others:

- 526 • Understand where and how information is processed, including collection practices and system
527 components that store and transmit this information (data flows and mapping)
- 528 • Understand the risks and benefits of collecting different data elements to determine if it should not
529 be collected
- 530 • Keep data only as long as needed for its function and destroy or de-identify it otherwise using
531 proper data lifecycle management practices and in accordance with applicable laws and policies
- 532 • Keep personal data segregated in a different repository, when practicable
- 533 • Encrypt data at rest, in transit, and in use
- 534 • Use role-based access controls
- 535 • Consider what measures should be taken to address predictability and manageability before
536 deciding whether data can be used beyond its initial expected and agreed upon use
- 537 • Implement privacy-enhancing technologies to increase disassociability while retaining confidentiality
538 and the capability to process data for mission or business purposes

539 5.3.1 User Login with Multifactor Authentication

540 Phishing-resistant multifactor authentication is a security best practice. The architecture recommends
541 the use of a password, pin (personal identification number) or biometric with an asymmetric
542 cryptographic key for authentication. However, it is common practice for organizations to offer a variety
543 of MFA solutions. This can include user-owned mobile devices, which may impact privacy risk [17].

544 Figure 5-1 Multifactor Authentication Data Flow Diagram



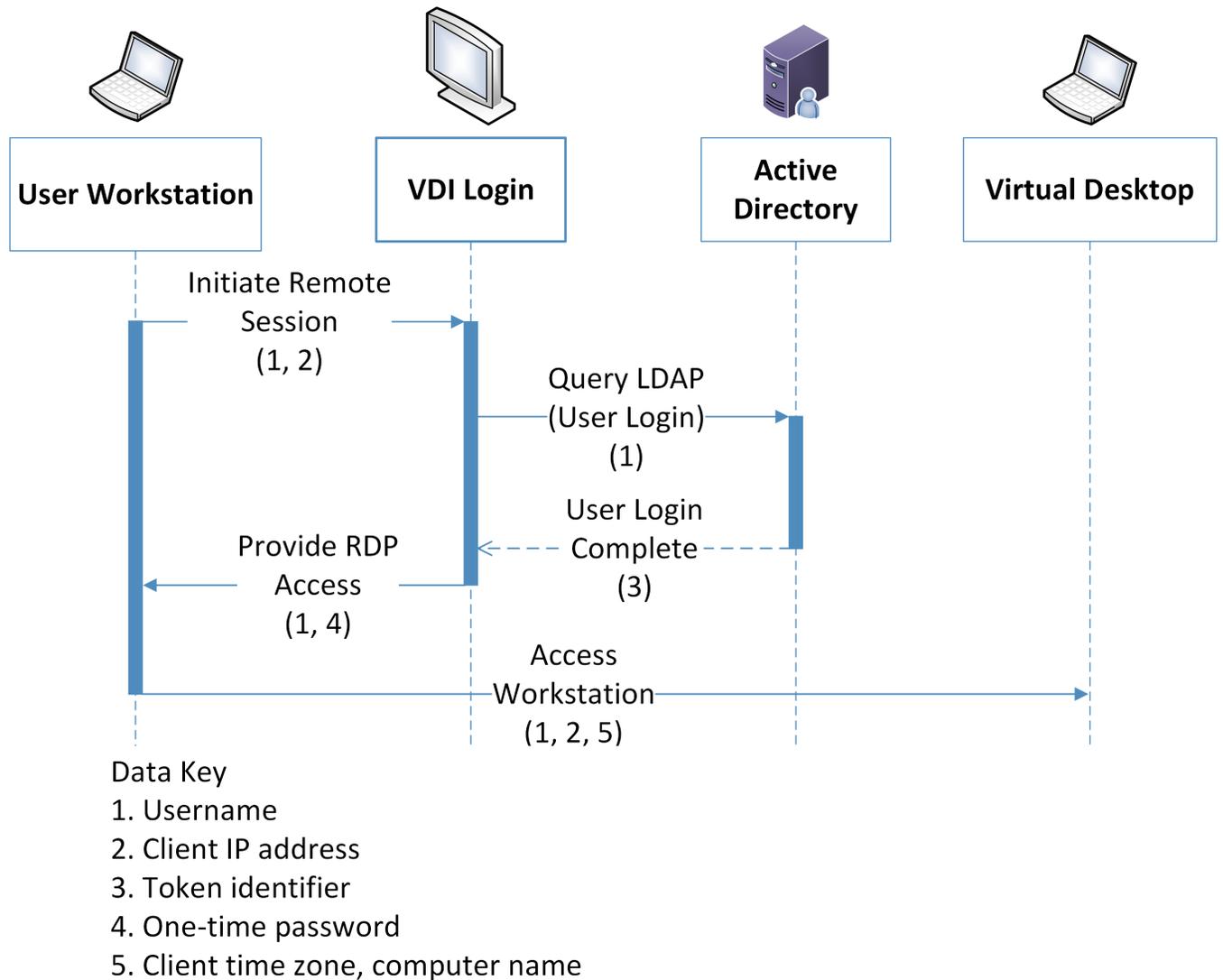
Data Type	Data Action	Privacy Impact
Username	Username is stored by the user workstation and transferred across the authentication process to help identify the transaction.	Usernames potentially contain inferable PII such as user's first and last names
Client IP Address	The client IP (Internet Protocol) address is stored by the user workstation, and transferred as part of communications where it is an endpoint.	IP addresses can be used to derive PII such as user's general location
Transaction Identifier	The transaction identifier is generated by active directory and transferred to the MFA solution and the mobile device.	Cross-component identifiers for a transaction can be used to re-identify information that was otherwise anonymized, such as connections between a user's name and their cell phone number.
Mobile device information	The mobile device information is stored by the MFA solution and the mobile device and transferred as a part of the communication between the mobile device and MFA solution.	Information about a user's mobile device, such as device type and version, can be used to infer privacy-impacting information such as the cost of their personal devices. Furthermore, user cell-phone numbers used in certain MFA transactions are PII.

Scenarios	Privacy Risk	Problematic Data Actions	Privacy Mitigations
<p>User authentication may use a mobile device as an authenticator, which can be personally or organizationally owned.</p>	<p>Mobile devices are a popular option for authentication processes. Personal information can be transferred in the process of authenticating. This can include phone number and location information. Users' non-work activity may be tracked by an organization.</p>	<p>Context: Authentication processes that utilize personally owned mobile devices can require the use of information that is personal to the user, such as phone numbers and other metadata. The tracking could extend beyond the work environment or even within the work environment be disproportionate to the security needs leading to unanticipated revelations about user activities or degradation of the dignity or autonomy of users.</p> <p>Problematic Data Action: Unanticipated Revelation, Induced Disclosure</p> <p>Problem: Loss of Autonomy: Users have no control over what information is shared in this scheme. Users may not feel comfortable using their own personal information as a security feature for an organizational service. Loss of Trust: Users may not feel comfortable with their personal phone numbers and device information being shared with third-party applications and Software as a Service providers.</p>	<p>Predictability: Organizations should inform users of information that is viewed and collected by login tools, such as through privacy notices when devices are enrolled. System administrators should have limited access to user authentication information</p> <p>Manageability: Organizations that leverage user's personal devices for user login processes should consider tools that give the users optionality for registering different types of authenticators, including those that do not use personal devices and information. In this build, Duo offers a variety of authentication options, such as a hardware-based authenticator.</p> <p>Organizations should audit tools to determine what information they are using and collecting.</p> <p>Disassociability: Organizations should explore capabilities and configurations that allow for the de-identification of phone numbers and other personal information, such as the capability to replace a phone number with placeholder text or privacy-enhancing cryptographic techniques to limit the tracking of users.</p>

545 **5.3.2 Authentication to Virtual Desktop Interface Solution**

546 The reference architecture in this document demonstrates a Virtual Desktop Interface (VDI) solution to
 547 facilitate secure access to organizational resources and data. Organizations may allow users' personal
 548 devices to access corporate resources using the VDI solution. Organizations should consider the privacy
 549 risk of installing VDI software on personally owned devices, information revealed by the VDI protocol,
 550 and monitoring of user activity while in the virtual environment.

551 **Figure 5-2 Virtual Desktop Interface Data Flow Diagram**



Data Type	Data Action	Privacy Impact
Username	The username is stored by the user workstation and active directory. It is transferred as part of the	Usernames potentially contain inferable PII such as user’s first and last names
Client IP Address	The Client IP Address is stored on the user workstation, and transferred as part of transactions and connections it generates.	IP addresses can be used to derive PII such as user’s general location
Token Identifier	A Token Identifier is generated by Active Directory in support of the authentication process and transferred to the VDI.	Token identifiers can be used to re-identify other information affecting privacy that occur as part of transactions.
One-time password	A One-time Password is generated by the VDI to authenticate the RDP (remote desktop protocol) connection and is transferred to and stored on the user workstation.	
Client Time Zone	The Client Time Zone is stored by the user workstation and transferred as part of an RDP connection to the virtual desktop.	Along with IP addresses, time zones specifically provide information about a user’s location
Client Computer Name	The Client Computer Name is stored by the user workstation and transferred as part of an RDP connection to the virtual desktop.	User’s personal device names can include inferable PII, such as personal names and device locations.

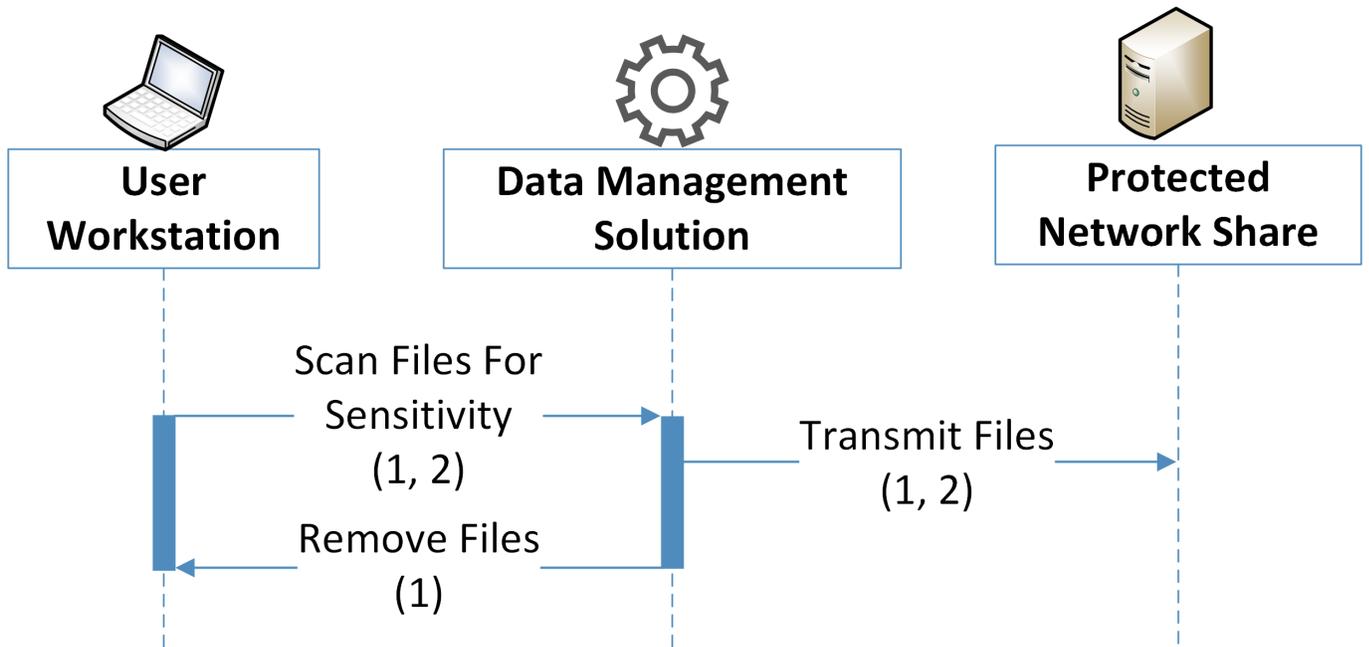
552

Scenarios	Privacy Risk	Problematic Data Actions	Privacy Mitigations
<p>User logs into a Virtual Desktop Interface solution from a personally or organizationally owned device.</p>	<p>Central login platforms can be connected to by a variety of devices, which may be personally owned by the user. Information that can be associated with the user, such as their device information or location, may be transmitted to security tools as part of the authentication process.</p>	<p>Context: Users operating under a BYOD or remote work scheme may not expect that certain data is under organizational purview. This can include their location, personal device metadata, and operating hours.</p> <p>Problematic Data Action: Surveillance, Unanticipated Revelation</p> <p>Problem:</p> <p>Loss of Trust. Users may not feel comfortable with this information being shared with third-party applications, or the company in general.</p> <p>Dignity Loss. Users may have information, such as their physical location and work hours, revealed to organizations in an undesired fashion.</p>	<p>Predictability: Users should be informed of information that is viewed and collected by login and network access tools such as Dispel, through either a login banner or other alert mechanism. Use privacy enhancing technologies and techniques to de-identify user, user ID and IP address like obfuscation, communication anonymization, data minimization, and pseudonymization, among others.</p> <p>Manageability: Organizations that include user's personal devices in day-to-day operation should audit tools to determine what information they are using and collecting and who has access rights</p> <p>Confidentiality: Organizations should mandate strict access control for the management and configuration of user login services, such as with MFA.</p> <p>Availability: Organizations that utilize central login platforms as their entry should consider the robustness of their platforms and systems. A loss of access to these systems can lead to an inability for users to access their data.</p>

554 **5.3.3 Automated Data Movement with Data Management Solution**

555 The reference architecture uses data management technology that allows for the scanning files for
556 highly sensitive information and establishment of policy that automatically moves sensitive content to
557 secure storage. Files with detected PII or other sensitive information may be moved in ways that are
558 unexpected to the user, potentially creating privacy concerns.

559 **Figure 5-3 Data Management Data Flow Diagram**



Data Key

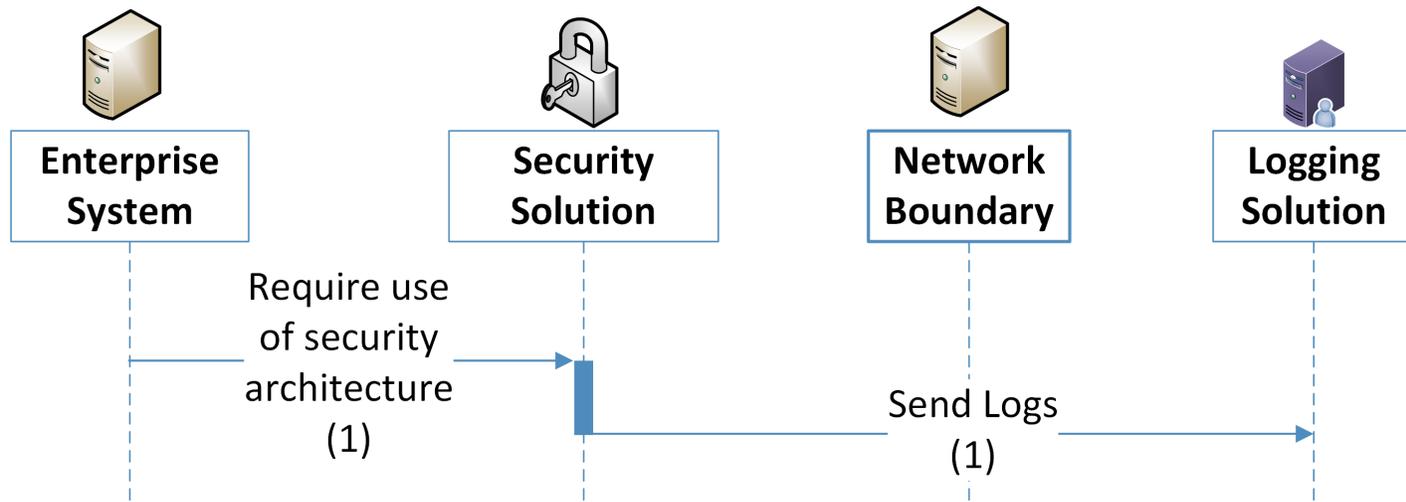
- 1. File metadata (Name, Date of Modification, File Type, Author)
- 2. File contents

Data Type	Data Action	Privacy Impact
File metadata	File metadata is stored on the user workstation, along with file contents. It is transferred along with file contents to the Data Management Solution and the Protected Network Share as part of the data movement operation. It is also used to identify data for deletion by the Data Management Solution.	File metadata can include information affecting privacy that is not derivable from file contents, such as the file name, date of modification, and author. This can be used to derive information such as active work hours and can lead to false assumptions about an individual
File contents	File contents are stored on the user workstation and transferred through the Data Management Solution to the Protected Network Share.	The privacy impact of file contents rely heavily on the data being used by an enterprise. This information can include SSNs, credit card information, health data, and other PII. Privacy impact and regulatory burden should be specifically considered and analyzed by organizations implementing these sorts of security solutions.

Scenarios	Privacy Risk	Problematic Data Actions	Privacy Mitigations
<p>Data generated in areas moderated by data management solutions are potentially duplicated, moved, or deleted in compliance with organizational policy.</p>	<p>Movement of data by external tools can lead to information being placed in unexpected or unintended places. This can lead to user confusion and a loss of trust in the organization, as well as data being made vulnerable to discovery and exfiltration</p>	<p>Context: Moving data from the place in which it was created or saved can create confusion for users and expose information in ways the user did not intend.</p> <p>Problematic Data Action: Appropriation, Unanticipated Revelation</p> <p>Problem:</p> <p>Loss of Trust. Users may be uncomfortable working in protected zones if they do not trust that their data will be kept under their control.</p> <p>Loss of Autonomy. Users may see involuntary data movement as a loss of their ability to govern the data they generate.</p>	<p>Predictability: Zones under the purview of data management and protection tools should be clearly defined and expressed to the user, such as through clearly understood network share names. Notice should be given to users who are impacted by the data management solution, such as by leaving a stub file at the original location.</p> <p>Manageability: Organizations seeking to include these capabilities should make sure they use solutions that can be configured to mitigate their inherent privacy risk.</p> <p>Confidentiality: Tools that provide the ability to analyze and move data should only be governed by system administrators. The automatic movement of data should only move data to locations only accessible by the user who created the original data or to folder with equal or more stringent access rights than the originating location. Furthermore, data locations are protected by IDAM (identity and access management controls) controls such as MFA.</p>

561 **5.3.4 Monitoring by Logging Solution**

562 This reference architecture generates logs used to aid in response and recovery activities. These logs are
 563 essential for proper data management and incident response. However organizations should consider
 564 the privacy of information collected by logs when they are created, transmitted and stored.

565 **Figure 5-4 Logging Data Flow Diagram****Data Key**

1. Usernames, IP addresses, web traffic history

566 The utilization of the security architecture, and the logs their user generates, can interact with and
 567 generate information that affects privacy. The use of a logging solution requires that data and metadata
 568 about user's activity be generated and stored in an additional location. Depending on the details and
 569 scope of the logging tool, this can extend the effective domain of information that affects privacy used
 570 by those tools. Some examples of information affecting privacy utilized in such transactions is given
 571 below:

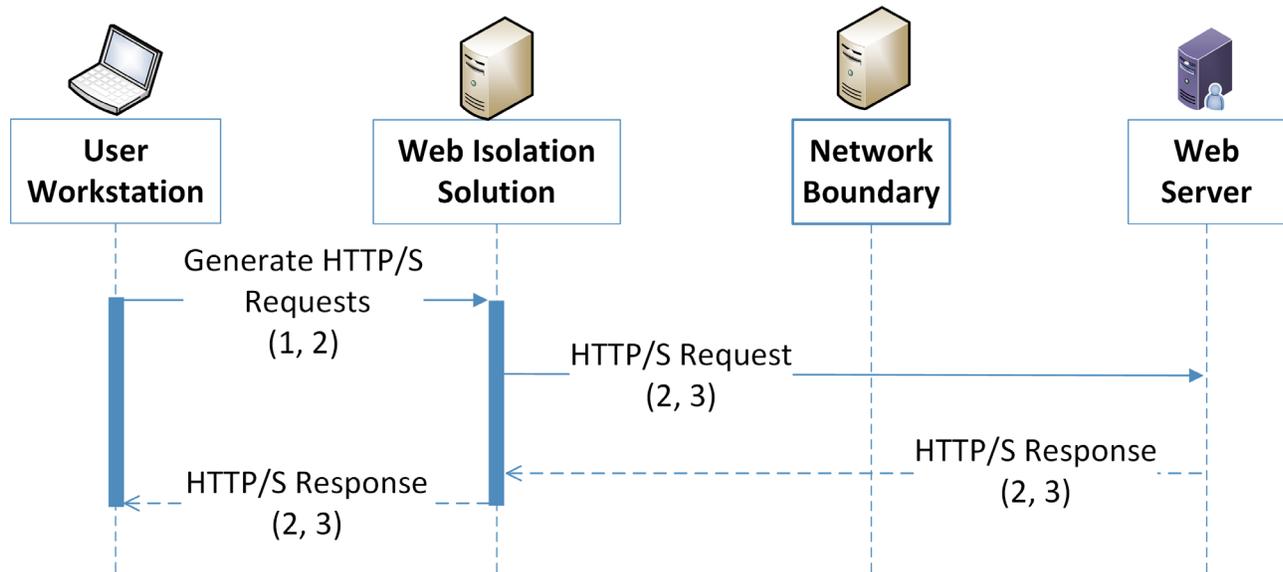
Data Type	Data Action	Privacy Impact
IP Addresses	IP Addresses are stored and transferred by enterprise systems as well as the logging solution. They are transferred by and through the security solutions.	IP addresses can be used to determine rough locations for user-owned machines. Additionally, IP Addresses can be common across logs from many security tools, allowing for anonymized data to be re-identified.
Device Identifiers	Device Identifiers are stored and transferred by enterprise systems as well as the logging solution. They are transferred by and through the security solutions.	Under certain circumstances, device Identifiers, such as MAC (media access control) addresses, can be used to identify individuals from data that has been de-identified, or allow for privacy-impacting correlations to be made between data logs.

Scenarios	Privacy Risk	Problematic Data Actions	Privacy Mitigations
<p>Security tools generate metadata that is transferred to a logging solution, either directly or via an on-site forwarder.</p>	<p>The security system passively creates data about users, their data, and their activities. This information is transmitted across the network and stored remotely.</p>	<p>Context: Logging systems can contain private data. These logs are transmitted off the device or system in which they were created to other systems where log information is aggregated. The privacy impact of each log and the aggregation of logs must be considered. Furthermore, this information is exposed to admin user who have access to either the individual or aggregated logs.</p> <p>Problematic Data Action: Unanticipated Revelation, Re-identification, Surveillance</p> <p>Problem:</p> <p>Loss of trust. Users may not expect the scope of information created and tracked by logs, even if they understand the scope of the security infrastructure.</p> <p>Dignity Loss. Embarrassing or undesired privacy information may be inferred about individuals whose actions generate logging information.</p>	<p>Predictability: The existence of monitoring systems should be disclosed to users upon their access to organizational systems, such as through a login banner. Use privacy enhancing technologies and techniques to de-identify user ID and IP address like obfuscation, communication anonymization, data minimization, and pseudonymization, among others.</p> <p>Manageability: Organizations should evaluate how logs can be configured to collect the least amount of information necessary in order to meet security needs, especially when security tools are aggregating log information across multiple systems.</p> <p>Disassociability: Organizations should consider de-identification functions for log creation, transmission, storage and aggregation. For example, privacy-relevant information such as the user’s name can be disassociated from their IP address or device identifier when collecting log information.</p> <p>Confidentiality: Tools that generate or store logs should have strict access control applied to them such as MFA.</p>

572 **5.3.5 User Web Browsing with Browser Isolation Solution**

573 Web isolation solutions must have governance over all user web traffic to be effective. This can generate
 574 privacy concerns to users by increasing the risk of their browsing data being misused.

575 **Figure 5-5 Browser Isolation Data Flow Diagram**



Data Key

- 1. Client IP Address
- 2. User browsing metadata (Target IP address, URL, Session information)
- 3. User browsing contents

Data Type	Data Action	Privacy Impact
Client IP Address	IP Addresses are stored on the User Workstation and sent by network connections to and from it.	IP addresses can be used to derive PII such as a user’s general location
User browsing metadata	User browsing metadata is generated on the user workstation and sent to and from the user workstation, as well as to and from the web isolation solution to the web server.	HTTP/S traffic, even when encrypted, relies on unencrypted metadata such as time stamps, source IPs, and destination IPs. These materials can be used to generate information that affects privacy, such as a specific user’s browsing habits.
User browsing contents	User browsing contents are generated on the user workstation as well as the web server. They are sent back and forth between the web server and the web isolation solution and delivered back to the user workstation.	Tools that can view and inspect the contents of a user’s web browsing session could further impact user privacy. This can include a user accessing their bank and checking balance information, accessing information from their healthcare provider, and so on.

Scenarios	Privacy Risk	Problematic Data Actions	Privacy Mitigations
<p>Data from user web browsing flows through web isolation solutions, centralizing information about employee web browsing.</p>	<p>Web monitoring tools are used to detect malicious web traffic patterns or access requests to unsafe domains but may also collect and transmit information that affects the user’s privacy.</p>	<p>Context: User browsing data can reveal information affecting privacy, such as personal health or financial information. Administrators can centrally view user browsing metadata at this location. This information may also be forwarded to other third-party tools.</p> <p>Problematic Data Action: Surveillance, Unanticipated Revelation</p> <p>Problem: Loss of Trust. Users may perceive the monitoring of their web traffic as a form of surveillance which may negatively impact the trust they have in their IT systems and/or organization.</p>	<p>Predictability: Users should be informed on the capabilities of web monitoring and related tools, such as through a login banner. Use privacy enhancing technologies and techniques to de-identify user ID and IP address like obfuscation, communication anonymization, data minimization, and pseudonymization, among others.</p> <p>Manageability: Organizations seeking to use web monitor tools should assess their privacy preserving capabilities. In this reference architecture Symantec Web Isolation provides a privacy toggle that allows for user browsing data to be anonymized.</p> <p>Disassociability: Organizations should employ de-identification options for data when appropriate. In this reference architecture the privacy toggle provided by Symantec Web Isolation was enabled, which anonymized user browsing data.</p> <p>Confidentiality: Organizations should mandate strict access controls for security tools that can impact user privacy, including the use of MFA.</p>

577 **6 Future Build Considerations**

578 As shown in [Figure 1-1](#), the NCCoE Data Security work that remains to be addressed within the
579 framework of the CIA triad is Data Availability. The Data Security team plans to evaluate the current
580 landscape of Data Availability challenges that organizations face and determine future relevant projects
581 to address those needs.

Appendix A**List of Acronyms**

API	Application Programming Interface
BYOD	Bring Your Own Device
CIA	Confidentiality Integrity Availability
CIS	Center for Internet Security
CNSSI	Committee on National Security Systems Instruction
COBIT	Control Objectives for Information and Related Technologies
CRADA	Cooperative Research And Development Agreement
CSC	Critical Security Controls
CSF	Cybersecurity Framework
FIPS	Federal Information Processing Standard
FIPPS	Fair Information Privacy Principles
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IDAM	Identity and Access Management
IEC	International Electrotechnical Commission
IP	Internet Protocol
ISA	International Society of Automation
ISO	International Organization for Standardization
IT	Information Technology
ITL	Information Technology Laboratory
MAC	Media Access Control
MFA	Multi Factor Authentication
NCCoE	National Cybersecurity Center of Excellence
NIST	National Institute of Standards and Technology
NIST IR	NIST Interagency or Internal Report
PDA	Problematic Data Action
PII	Personally Identifiable Information
PIN	Personal Identification Number
PRAM	Privacy Risk Assessment Methodology
RDP	Remote Desktop Protocol
RMF	Risk Management Framework
SMS	Short Messaging Service
SP	Special Publication
URL	Uniform Resource Locator
USB	Universal Series Bus

DRAFT

VDI

Virtual Desktop Interface

Access Control

The process of granting or denying specific requests to 1) obtain and use information and related information processing services and 2) enter specific physical facilities (e.g., federal buildings, military establishments, border crossing entrances).

SOURCE: Federal Information Processing Standard (FIPS) 201-3

Adversary

Person, group, organization, or government that conducts or has the intent to conduct detrimental activities.

SOURCE: CNSSI 4009-2015

Asset

A major application, general support system, high impact program, physical plant, mission critical system, personnel, equipment, or a logically related group of systems.

SOURCE: Committee on National Security Systems Instruction (CNSSI) 4009-2015

Authentication

Verifying the identity of a user, process, or device, often as a prerequisite to allowing access to resources in an information system.

SOURCE: FIPS 200

Authorization

Access privileges granted to a user, program, or process or the act of granting those privileges.

SOURCE: CNSSI 4009-2015

Breach

The loss of control, compromise, unauthorized disclosure, unauthorized acquisition, or any similar occurrence where: a person other than an authorized user accesses or potentially accesses personally identifiable information; or an authorized user accesses personally identifiable information for another than authorized purpose.

SOURCE: NIST SP 800-53 Rev. 5

Control

The means of managing risk, including policies, procedures, guidelines, practices, or organizational structures, which can be of an administrative, technical, management, or legal nature.

SOURCE: NIST SP 800-160 Vol. 2 Rev. 1

Confidentiality	<p>Preserving authorized restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information.</p> <p>SOURCE: FIPS 200</p>
Data	<p>A subset of information in an electronic format that allows it to be retrieved or transmitted.</p> <p>SOURCE: CNSSI 4008-2015</p>
Data Action	<p>A system/product/service data life cycle operation, including, but not limited to collection, retention, logging, generation, transformation, use, disclosure, sharing, transmission, and disposal.</p> <p>SOURCE: NIST Privacy Framework Version 1.0</p>
Disassociability	<p>Enabling the processing of PII or events without association to individuals or devices beyond the operational requirements of the system.</p> <p>SOURCE: NISTIR 8062</p>
Encrypt	<p>Cryptographically transform data to produce cipher text.</p> <p>SOURCE: CNSSI 4009-2015</p>
Enterprise	<p>An entity of any size, complexity, or positioning within an organizational structure.</p> <p>SOURCE: NIST SP 800-72</p>
Event	<p>Any observable occurrence in a network or system.</p> <p>SOURCE: CNSSI 4009-2015</p>
Exfiltration	<p>The unauthorized transfer of information from an information system.</p> <p>SOURCE: CNSSI 4009-2015</p>
Incident	<p>An occurrence that actually or potentially jeopardizes the confidentiality, integrity, or availability of an information system or the information the system processes, stores, or transmits or that constitutes a violation or imminent threat of violation of security policies, security procedures, or acceptable use policies.</p> <p>SOURCE: FIPS 200</p>

Integrity Guarding against improper information modification or destruction and includes ensuring information non-repudiation and authenticity.

SOURCE: FIPS 200

Key Management The activities involving handling of cryptographic keys and other related security parameters (e.g. passwords) during the entire life cycle of the keys, including their generation, storage, establishment, entry and output, and destruction.

SOURCE: CNSSI 4009-2015

Manageability Providing the capability for granular administration of PII including alteration, deletion, and selective disclosure.

SOURCE: NISTIR 8062

Malware Hardware, firmware, or software that is intentionally included or inserted in a system for a harmful purpose.

SOURCE: CNSSI 4009-2015

Mitigation A decision, action, or practice intended to reduce the level of risk associated with one or more threat events, threat scenarios, or vulnerabilities.

SOURCE: NIST SP 1800-160 Vol. 2 Rev. 1

Multi-Factor Authentication Authentication using two or more factors to achieve authentication. Factors include: (i) something you know (e.g. password/personal identification number (PIN)); (ii) something you have (e.g., cryptographic identification device, token); or (iii) something you are (e.g., biometric).

SOURCE: CNSSI 4009-2015

Phishing A technique for attempting to acquire sensitive data, such as bank account numbers, through a fraudulent solicitation in email or on a web site, in which the perpetrator masquerades as a legitimate business or reputable person.

SOURCE: CNSSI 4009-2015

Predictability Enabling reliable assumptions by individuals, owners, and operators about PII and its processing by a system.

SOURCE: NISTIR 8062

Risk The level of impact on organizational operations (including mission, functions, image, or reputation), organizational assets, or individuals resulting from the operation of an information system given the potential impact of a threat and the likelihood of that threat occurring.

SOURCE: FIPS 200

Security Control The safeguards or countermeasures prescribed for an information system or an organization to protect the confidentiality, integrity, and availability of the system and its information.

SOURCE: NIST SP 800-53

Security Policy A set of rules that governs all aspects of security-relevant system and system component behavior.

SOURCE: NIST SP 800-53 Rev. 5

Spear Phishing A colloquial term that can be used to describe any highly targeted phishing attack.

SOURCE: CNSSI 4009-2015

Threat Any circumstance or event with the potential to adversely impact organizational operations, organizational assets, individuals, other organizations, or the Nation through a system via unauthorized access, destruction, disclosure, modification of information, and/or denial of service.

SOURCE: NIST SP 800-53 Rev. 5

Vulnerability Weakness in an information system, system security procedures, internal controls, or implementation that could be exploited or triggered by a threat source.

SOURCE: FIPS 200

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637 **Appendix D Security Control Map**

638 The following table lists the NIST Cybersecurity Framework Functions, Categories, and Subcategories
 639 addressed by this project and maps them to relevant NIST standards, industry standards, and controls
 640 and best practices.

641 **Table 6-1 Security Control Map**

Cybersecurity Framework v1.1			Standards & Best Practices
Function	Category	Subcategory	Informative References
IDENTIFY (ID)	Asset Management (ID.AM)	ID.AM-2: Software platforms and applications within the organization are inventoried	CIS CSC 2 COBIT 5 BAI09.01, BAI09.02, BAI09.05 ISA 62443-2-1:2009 4.2.3.4 ISA 62443-3-3:2013 SR 7.8 ISO/IEC 27001:2013 A.8.1.1, A.8.1.2, A.12.5.1 NIST SP 800-53 Rev. 4 CM-8, PM-5
	Risk Assessment (ID.RA)	ID.RA-1: Asset vulnerabilities are identified and documented	CIS CSC 4 COBIT 5 APO12.01, APO12.02, APO12.03, APO12.04, DSS05.01, DSS05.02 ISA 62443-2-1:2009 4.2.3, 4.2.3.7, 4.2.3.9, 4.2.3.12 ISO/IEC 27001:2013 A.12.6.1, A.18.2.3 NIST SP 800-53 Rev. 4 CA-2, CA-7, CA-8, RA3, RA-5, SA-5, SA-11, SI-2, SI-4, SI-5
		ID.RA-2: Cyber threat intelligence is received from information sharing forums and sources	CIS CSC 4 COBIT 5 BAI08.01 ISA 62443-2-1:2009 4.2.3, 4.2.3.9, 4.2.3.12 ISO/IEC 27001:2013 A.6.1.4 NIST SP 800-53 Rev. 4 SI-5, PM-15, PM-16

Cybersecurity Framework v1.1			Standards & Best Practices
Function	Category	Subcategory	Informative References
		ID.RA-3: Threats, both internal and external, are identified and documented	CIS CSC 4 COBIT 5 APO12.01, APO12.02, APO12.03, APO12.04 ISA 62443-2-1:2009 4.2.3, 4.2.3.9, 4.2.3.12 ISO/IEC 27001:2013 Clause 6.1.2 NIST SP 800-53 Rev. 4 RA-3, SI-5, PM-12, PM16
PROTECT (PR)	Identity Management, Authentication and AccessControl (PR.AC)	PR.AC-1: Identities and credentials are issued, managed, verified, revoked, and audited for authorized devices, users and processes	CIS CSC 1, 5, 15, 16 COBIT 5 DSS05.04, DSS06.03 ISA 62443-2-1:2009 4.3.3.5.1 ISA 62443-3-3:2013 SR 1.1, SR 1.2, SR 1.3, SR 1.4, SR 1.5, SR 1.7, SR 1.8, SR 1.9 ISO/IEC 27001:2013 A.9.2.1, A.9.2.2, A.9.2.3, A.9.2.4, A.9.2.6, A.9.3.1, A.9.4.2, A.9.4.3 NIST SP 800-53 Rev. 4 AC-1, AC-2, IA-1, IA-2, IA-3, IA-4, IA-5, IA-6, IA-7, IA-8, IA-9, IA-10, IA-11
		PR.AC-3: Remote access is managed	CIS CSC 12 COBIT 5 APO13.01, DSS01.04, DSS05.03 ISA 62443-2-1:2009 4.3.3.6.6 ISA 62443-3-3:2013 SR 1.13, SR 2.6 ISO/IEC 27001:2013 A.6.2.1, A.6.2.2, A.11.2.6, A.13.1.1, A.13.2.1 NIST SP 800-53 Rev. 4 AC-1, AC-17, AC-19, AC-20, SC-15
		PR.AC-4: Access permissions and authorizations are managed, incorporating the principles of least privilege and separation of duties	CIS CSC 3, 5, 12, 14, 15, 16, 18 COBIT 5 DSS05.04 ISA 62443-2-1:2009 4.3.3.7.3 ISA 62443-3-3:2013 SR 2.1 ISO/IEC 27001:2013 A.6.1.2, A.9.1.2, A.9.2.3, A.9.4.1, A.9.4.4, A.9.4.5 NIST SP 800-53 Rev. 4 AC-1, AC-2, AC-3, AC5, AC-6, AC-14, AC-16, AC-24

Cybersecurity Framework v1.1			Standards & Best Practices
Function	Category	Subcategory	Informative References
		PR.AC-5: Network integrity is protected (e.g., network segregation, network segmentation)	CIS CSC 9, 14, 15, 18 COBIT 5 DSS01.05, DSS05.02 ISA 62443-2-1:2009 4.3.3.4 ISA 62443-3-3:2013 SR 3.1, SR 3.8 ISO/IEC 27001:2013 A.13.1.1, A.13.1.3, A.13.2.1, A.14.1.2, A.14.1.3 NIST SP 800-53 Rev. 4 AC-4, AC-10, SC-7
		PR.AC-7: Users, devices, and other assets are authenticated (e.g., single-factor, multi-factor) commensurate with the risk of the transaction (e.g., individuals' security and privacy risks and other organizational risks)	CIS CSC 1, 12, 15, 16 COBIT 5 DSS05.04, DSS05.10, DSS06.10 ISA 62443-2-1:2009 4.3.3.6.1, 4.3.3.6.2, 4.3.3.6.3, 4.3.3.6.4, 4.3.3.6.5, 4.3.3.6.6, 4.3.3.6.7, 4.3.3.6.8, 4.3.3.6.9
	Data Security (PR.DS)	PR.DS-1: Data-at-rest is protected	CIS CSC 13, 14 COBIT 5 APO01.06, BAI02.01, BAI06.01, DSS04.07, DSS05.03, DSS06.06 ISA 62443-3-3:2013 SR 3.4, SR 4.1 ISO/IEC 27001:2013 A.8.2.3 NIST SP 800-53 Rev. 4 MP-8, SC-12, SC-28
		PR.DS-2: Data-in-transit is protected	CIS CSC 13, 14 COBIT 5 APO01.06, DSS05.02, DSS06.06 ISA 62443-3-3:2013 SR 3.1, SR 3.8, SR 4.1, SR 4.2 ISO/IEC 27001:2013 A.8.2.3, A.13.1.1, A.13.2.1, A.13.2.3, A.14.1.2, A.14.1.3 NIST SP 800-53 Rev. 4 SC-8, SC-11, SC-12

Cybersecurity Framework v1.1			Standards & Best Practices
Function	Category	Subcategory	Informative References
		PR.DS-3: Assets are formally managed throughout removal, transfers, and disposition	CIS CSC 1 COBIT 5 BAI09.03 ISA 62443-2-1:2009 4.3.3.3.9, 4.3.4.4.1 ISA 62443-3-3:2013 SR 4.2 ISO/IEC 27001:2013 A.8.2.3, A.8.3.1, A.8.3.2, A.8.3.3, A.11.2.5, A.11.2.7 NIST SP 800-53 Rev. 4 CM-8, MP-6, PE-16
	Information Protection Processes and Procedures (PR.IP)	PR.IP-5: Policy and regulations regarding the physical operating environment for organizational assets are met	CIS CSC 10 COBIT 5 APO13.01, DSS01.01, DSS04.07 ISA 62443-2-1:2009 4.3.4.3.9 ISA 62443-3-3:2013 SR 7.3, SR 7.4 ISO/IEC 27001:2013 A.12.3.1, A.17.1.2, A.17.1.3, A.18.1.3 NIST SP 800-53 Rev. 4 CP-4, CP-6, CP-9
	Protective Technology (PR.PT)	PR.PT-1: Audit/log records are determined, documented, implemented, and reviewed in accordance with policy	CIS CSC 1, 3, 5, 6, 14, 15, 16 COBIT 5 APO11.04, BAI03.05, DSS05.04, DSS05.07, MEA02.01 ISA 62443-2-1:2009 4.3.3.3.9, 4.3.3.5.8, 4.3.4.4.7, 4.4.2.1, 4.4.2.2, 4.4.2.4 ISA 62443-3-3:2013 SR 2.8, SR 2.9, SR 2.10, SR 2.11, SR 2.12 ISO/IEC 27001:2013 A.12.4.1, A.12.4.2, A.12.4.3, A.12.4.4, A.12.7.1 NIST SP 800-53 Rev. 4 AU Family

642 **Appendix E Privacy Control Map**

643 The following table lists the NIST Privacy Framework Functions, Categories, and Subcategories addressed by this project and maps them to
 644 relevant NIST standards, industry standards, and controls and best practices.

645 NOTE: The International Organization for Standardization (ISO) standard 27701 references were not mapped by NIST, but by an external
 646 organization. They are available at the NIST Privacy Framework Repository [18] and provided here for convenience. The Fair Information
 647 Privacy Principles (FIPPS) references are provided to aid understanding of the Privacy Control Map.

648 **Table 6-2 Privacy Control Map**

Privacy Framework 1.0				Standards and Best Practices
	Function	Category	Subcategory	Informative References
	IDENTIFY-P (ID-P): Develop the organizational understanding to manage privacy risk for individuals arising from data processing.	Inventory and Mapping (ID.IM-P): Data processing by systems, products, or services is understood and informs the management of privacy risk.	ID.IM-P1: Systems/products/services that process data are inventoried.	FIPPS 7: Purpose Specification/Use Limitation NIST SP 800-37 Rev. 2: Task P-10 NIST SP 800-53 Rev. 5: CM-8 (10), CM-12, CM-13, PM-5 NIST IR 8062 NIST PRAM: Worksheet 2 ISO/IEC 27701:2019 7.2.8, 8.2.6
	CONTROL-P (CT-P): Develop and Optional (Risk Based) appropriate activities to enable organizations or individuals to manage data with sufficient granularity to manage privacy risks.	Data Processing Management (CT.DM-P): Data are managed consistent with the organization’s risk strategy to protect individuals’ privacy, increase manageability, and enable the implementation of privacy principles (e.g., individual participation, data quality, data minimization).	CT.DM-P8: Audit/log records are determined, documented, and reviewed in accordance with policy and incorporating the principle of data minimization.	FIPPS 4: Minimization NIST SP 800-53 Rev. 5: AU-1, AU-2, AU-3, AU-6, AU-7, AU-12, AU-13, AU-14, AU-16 NIST IR 8062 ISO/IEC 27701:2019 6.9.4.1, 6.9.4.2, 6.15.1.3

Privacy Framework 1.0				Standards and Best Practices
	Function	Category	Subcategory	Informative References
		<p>Disassociated Processing (CT.DP-P): Data processing solutions increase disassociability consistent with the organization’s risk strategy to protect individuals’ privacy and enable implementation of privacy principles (e.g., data minimization).</p>	<p>CT.DP-P2: Data are processed to limit the identification of individuals (e.g., de-identification privacy techniques, tokenization).</p>	<p>FIPPS 7: Purpose Specification/Use Limitation NIST SP 800-53 Rev. 5: AC-23, AU-3(3), IA-4(8), PE-8(3), SA-8(33), SI-12(1), SI-12(2), SI-19 NIST SP 800-63-3 NIST SP 800-188 (draft) NIST IR 8053 NIST IR 8062 ISO/IEC 27701:2019 7.4.2, 7.4.4</p>
		<p>Data Processing Awareness (CM.AW-P): Individuals and organizations have reliable knowledge about data processing practices and associated privacy risks, and effective mechanisms are used and maintained to increase predictability consistent with the organization’s risk strategy to protect individuals’ privacy.</p>	<p>CM.AW-P3: System/product/service design enables data processing visibility.</p>	<p>FIPPS 7: Purpose Specification/Use Limitation NIST SP 800-53 Rev. 5: PL-8, PT-5(1), SA-17, SC-42(4) NIST IR 8062 ISO/IEC 27701:2019 7.3.2, 7.3.3, 8.3.1</p>
	<p>PROTECT-P (PR-P): Develop and Implement appropriate data processing safeguards.</p>	<p>Data Protection Policies, Processes, and Procedures (PR.PO-P): Security and privacy policies (e.g., purpose, scope, roles and responsibilities in the data processing ecosystem, and</p>	<p>PR.PO-P4: Policy and regulations regarding the physical operating environment for organizational assets are met.</p>	<p>FIPPS 5: Quality and Integrity FIPPS 7: Purpose Specification/Use Limitation NIST SP 800-53 Rev. 5: PE-1 ISO/IEC 27701:2019 All of 6.8</p>

Privacy Framework 1.0			Standards and Best Practices
Function	Category	Subcategory	Informative References
	<p>management commitment), processes, and procedures are maintained and used to manage the protection of data.</p> <p>Identity Management, Authentication, and Access Control (PR.AC-P): Access to data and devices is limited to authorized individuals, processes, and devices, and is managed consistent with the assessed risk of unauthorized access.</p>		
		<p>PR.AC-P1: Identities and credentials are issued, managed, verified, revoked, and audited for authorized individuals, processes, and devices.</p>	<p>FIPPS 8: Security NIST SP 800-53 Rev. 5: IA-1, IA-2, IA-3, IA-4, IA-5, IA-7, IA-8, IA-9, IA-10, IA-11, IA-12 NIST SP 800-63-3 ISO/IEC 27701:2019 6.6.2.1, 6.6.2.2, 6.6.4.2</p>
		<p>PR.AC-P3: Remote access is managed.</p>	<p>FIPPS 8: Security FIPS Publication 199 NIST SP 800-46 Rev. 2 NIST SP 800-53 Rev. 5: AC-1, AC-17, AC-19, AC-20, SC-15 NIST SP 800-77 NIST SP 800-113 NIST SP 800-114 Rev. 1 NIST SP 800-121 Rev. 2 ISO/IEC 27701:2019 6.6.2.1, 6.6.2.2</p>
	<p>PR.AC-P4: Access permissions and authorizations are managed, incorporating the principles of least privilege and separation of duties.</p>	<p>FIPPS 8: Security NIST SP 800-53 Rev. 5: AC-1, AC-2, AC-3, AC-5, AC-6, AC-14, AC-16, AC-24 NIST SP 800-162</p>	

Privacy Framework 1.0				Standards and Best Practices
	Function	Category	Subcategory	Informative References
			PR.AC-P5: Network integrity is protected (e.g., network segregation, network segmentation).	FIPPS 8: Security NIST SP 800-53 Rev. 5: AC-4, AC-10, SC-7, SC-10, SC-20
			PR.AC-P6: Individuals and devices are proofed and bound to credentials and authenticated commensurate with the risk of the transaction (e.g., individuals' security and privacy risks and other organizational risks).	FIPPS 8: Security NIST SP 800-53 Rev. 5: AC-14, AC-16, IA-1, IA-2, IA-3, IA-4, IA-5, IA-8, IA-9, IA-10, IA-11, IA-12, PE-2, PS-3 NIST SP 800-63-3
		Data Security (PR.DS-P): Data are managed consistent with the organization's risk strategy to protect individuals' privacy and maintain data confidentiality, integrity, and availability.	PR.DS-P1: Data-at-rest are protected.	FIPPS 8: Security NIST SP 800-53 Rev. 5: MP-2, MP-3, MP-4, MP-5, MP-6, MP-7, MP-8, SC-28 NIST SP 800-175B
			PR.DS-P2: Data-in-transit are protected.	FIPPS 8: Security NIST SP 800-53 Rev. 5: SC-8, SC-11 NIST SP 800-175B
			PR.DS-P3: Systems/products/services and associated data are formally managed throughout removal, transfers, and disposition.	FIPPS 8: Security NIST SP 800-53 Rev. 5: CM-8, MP-6, PE-16, PE-20